

# Microphysical Characteristics and Nucleation Mechanisms in Synoptic Cirrus

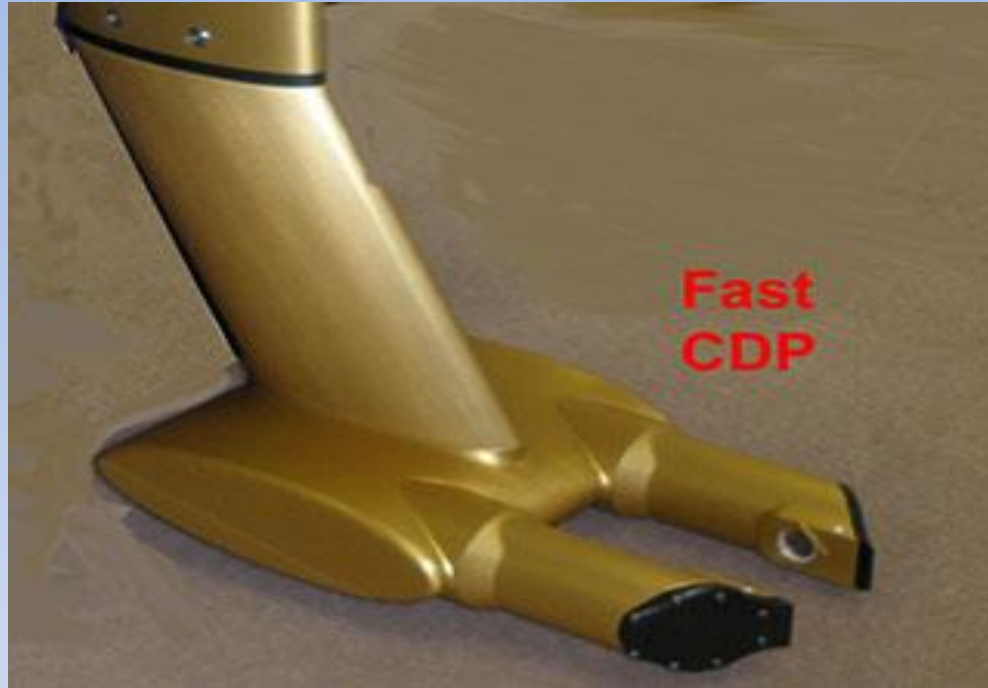
S. Woods <sup>a</sup>, S. Lance <sup>a</sup>, B. Gandrud <sup>a</sup>, R. P. Lawson <sup>a</sup>, R. Herman <sup>c</sup> , and T. P. Bui <sup>b</sup>

-SPEC Inc, Boulder, CO <sup>a</sup>

-NASA Ames Research Center, Mountain View, CA <sup>b</sup>

-NASA Jet Propulsion Laboratory, Pasadena, CA <sup>c</sup>

# Fast Cloud Droplet Probe (FCDP)



- count & size based on forward scattering
- design to eliminate/reduce shattering
- 1 to 50  $\mu$  diameter with oversize bin
- modern high speed electronics w/ pbp

<http://www.specinc.com/instrumentation>

# FCDP location on ER2



- ER2 used mostly as a remote sensor platform
- FCDP was late edition to payload
- cloud/no cloud at flight altitude

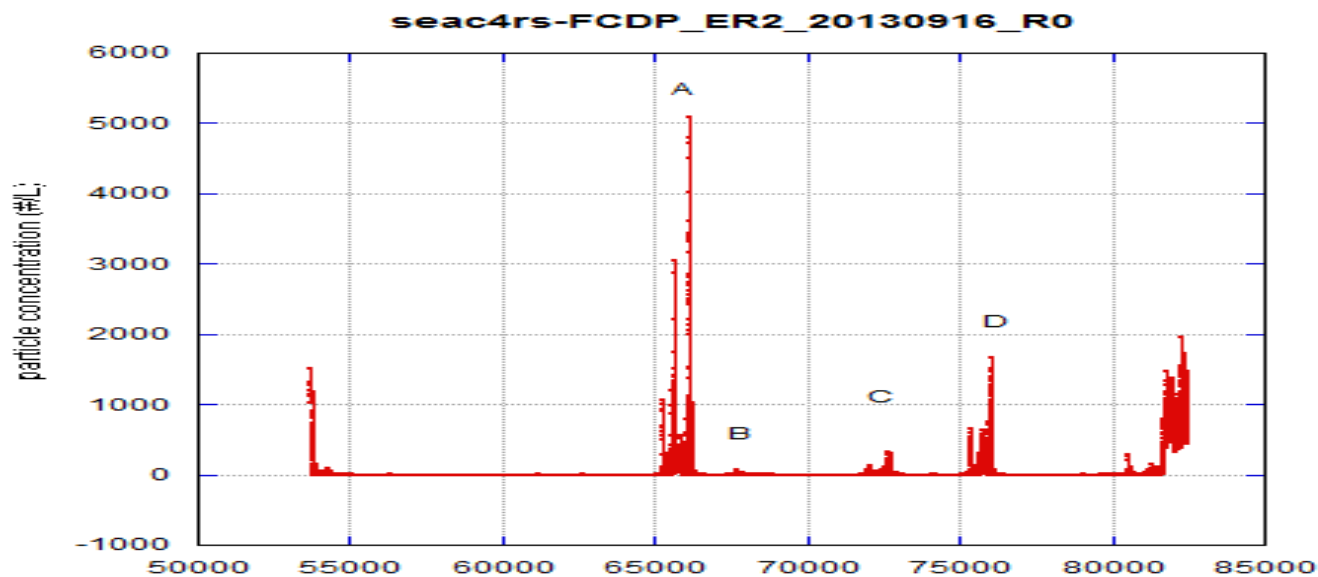
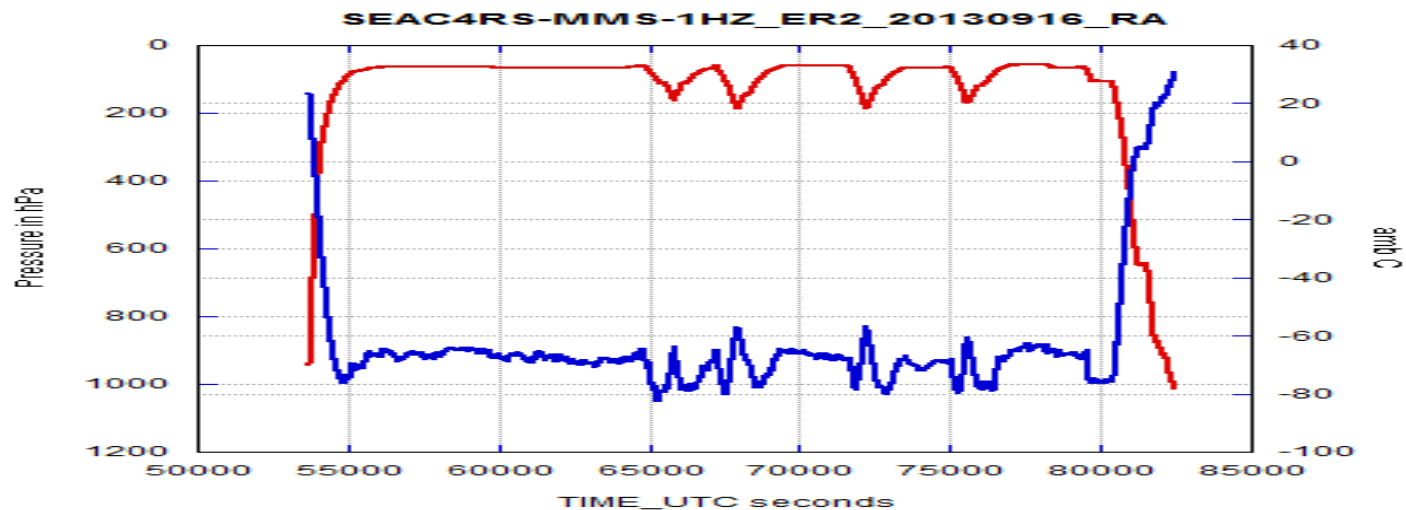
# FCDP data summary

- Operational on all 20 science flights
- Cirrus cloud particles observed for short periods on 6 flights during vertical profiles from flight altitude
- 9 of 9 clouds show cirrus concentrations  $<200 \text{ L}^{-1}$  in thin layers, not just below clouds
- 2 of 9 clouds show cirrus concentrations in the  $>2000 \text{ L}^{-1}$  range

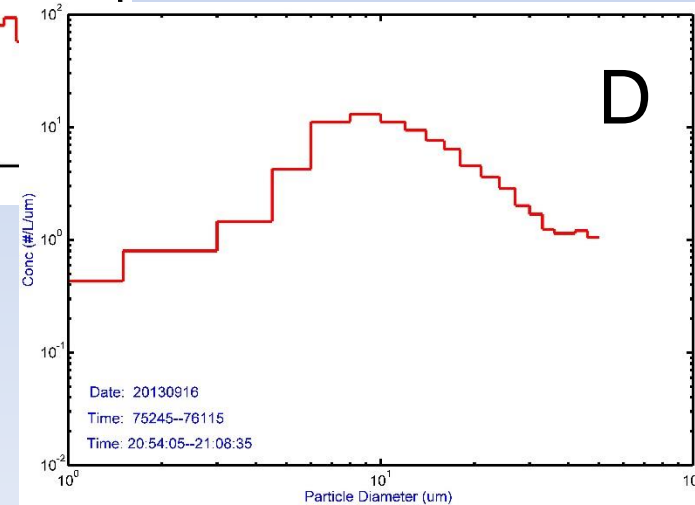
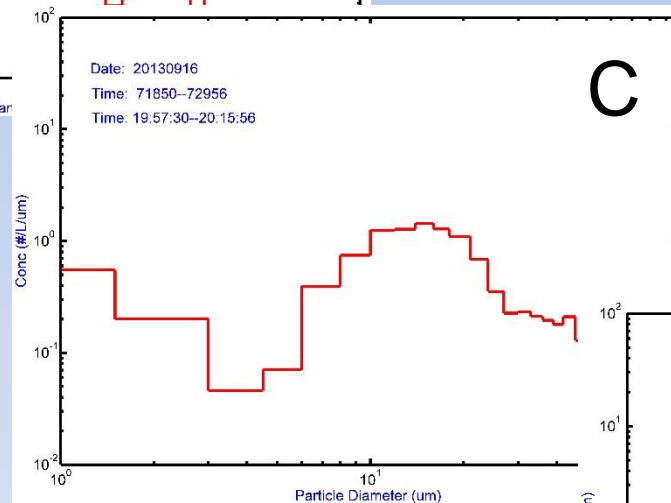
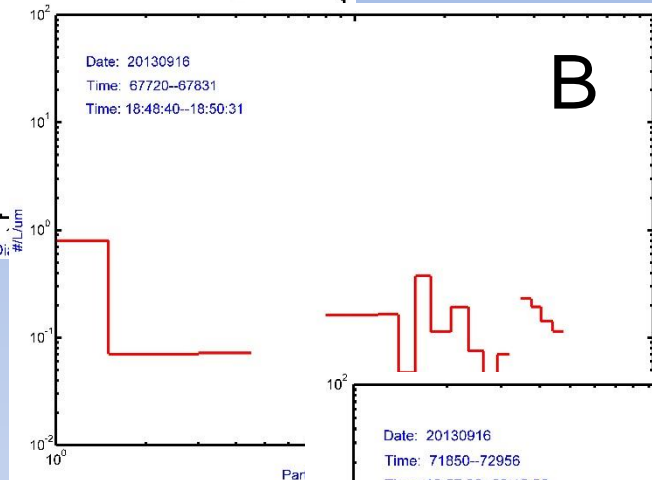
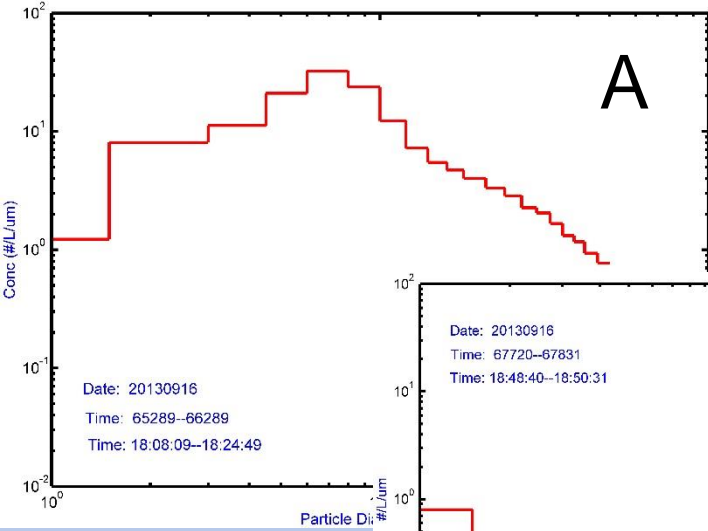
# 9 cloud dates & times

aircraft	date&flight	start sec	end sec		description
ER2	20130902SF11	79550	79986		36um & oversize
ER2	20130904SF12	72170	72230		upper end of FCDP
ER2	20130913SF16	59400	59800		large end on FCDP
ER2	20130916SF17	65289	66289		4-10 um
ER2	20130916SF17	67720	67831		few counts mid range
ER2	20130916SF17	71850	72956		few counts mid range
ER2	20130916SF17	75245	76115		few counts mid range
ER2	20130918SF18	62270	62574		few small, few large
ER2	20130922SF19	56700	56880		few big & overs

# 20130916 flight SF17



# 20130916 PSDs



- 4 profiles over Gulf of Mexico
- size & concentration very different between profiles
- why?

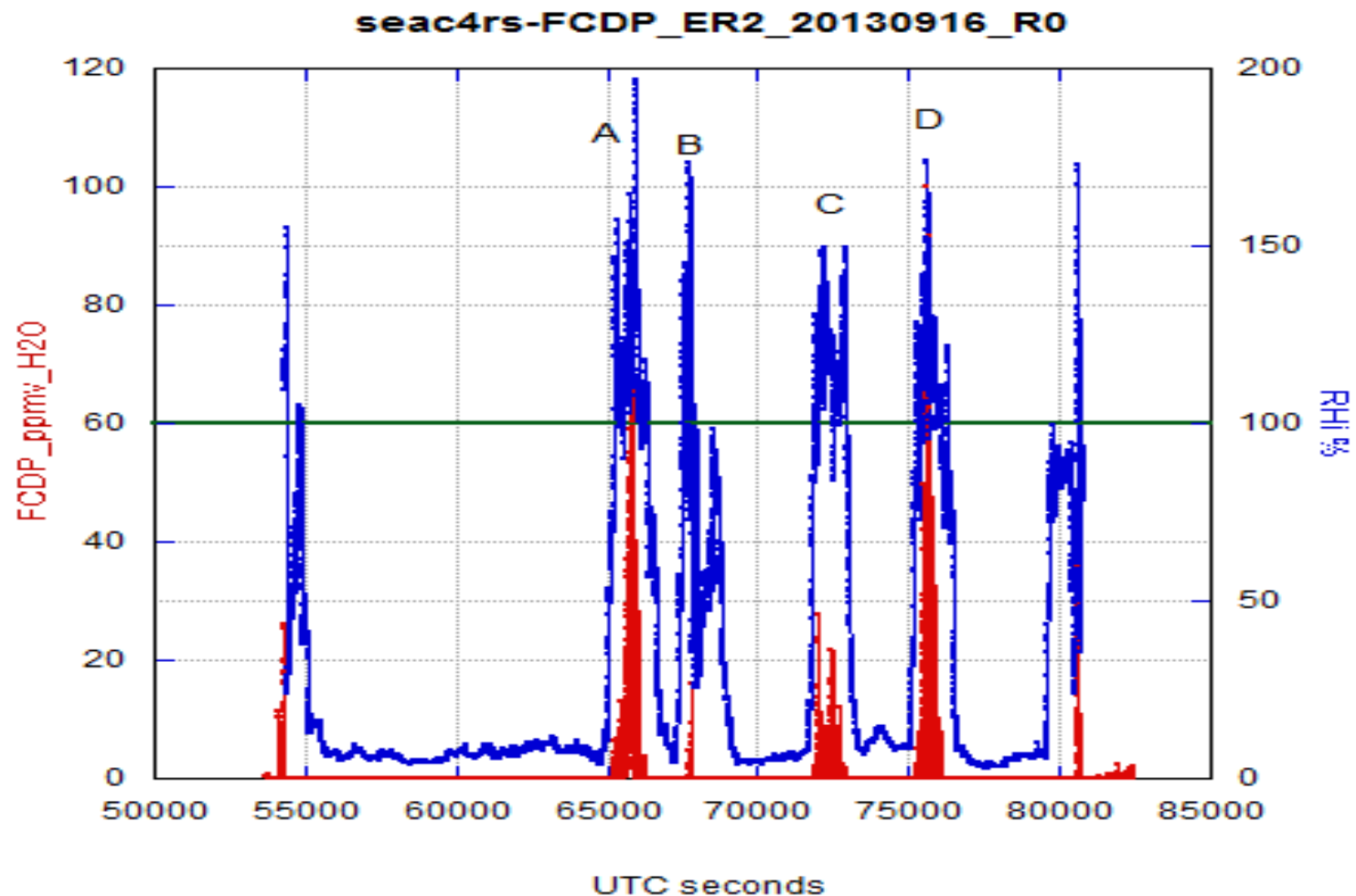
# Supporting measurements

- NASA J LH (Herman), open path WV
- NASA Meteorological Measurement System (Bui)
  - T, P, winds, latitude & longitude
- multiple WV measurements

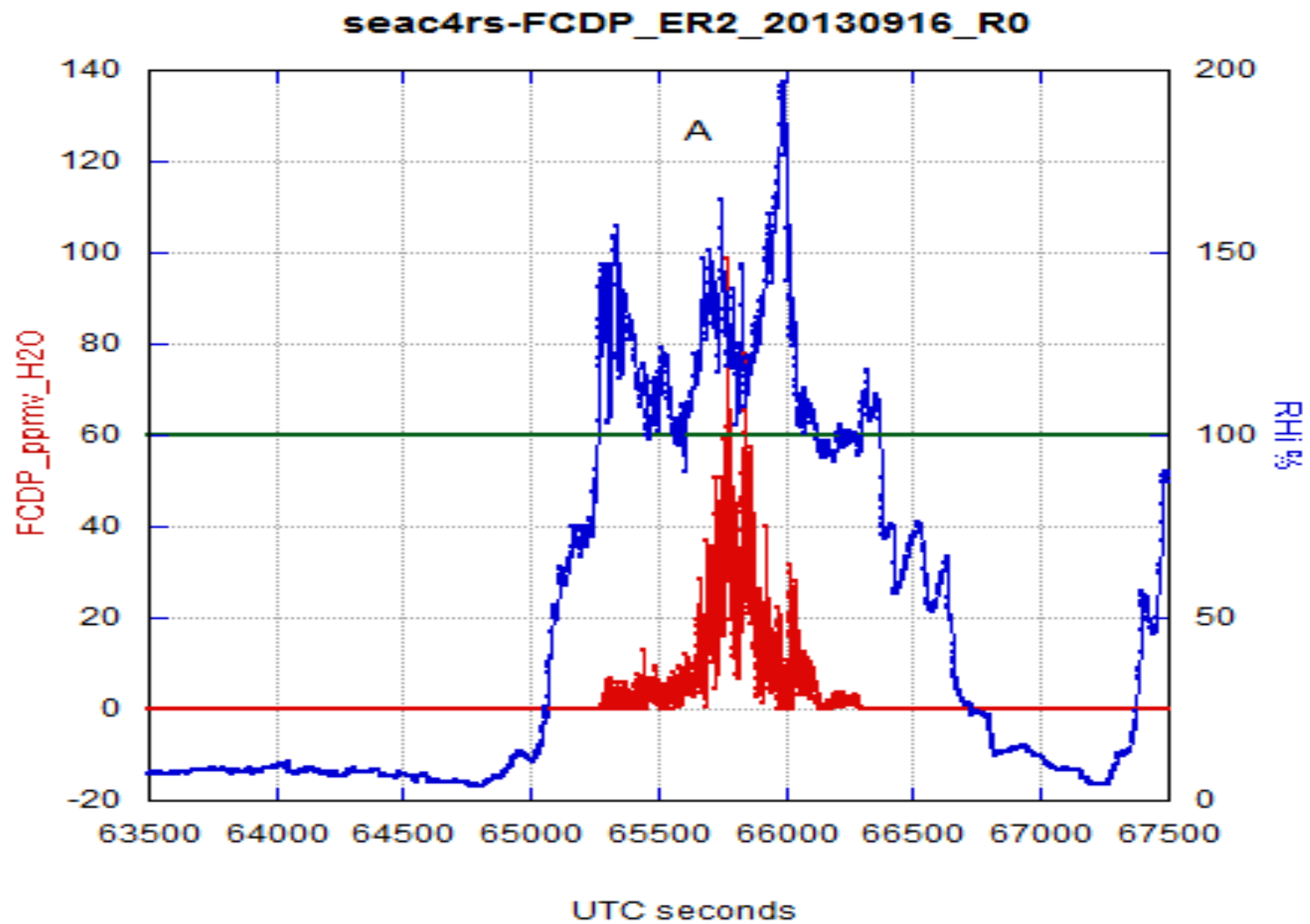


# Previous cirrus insights

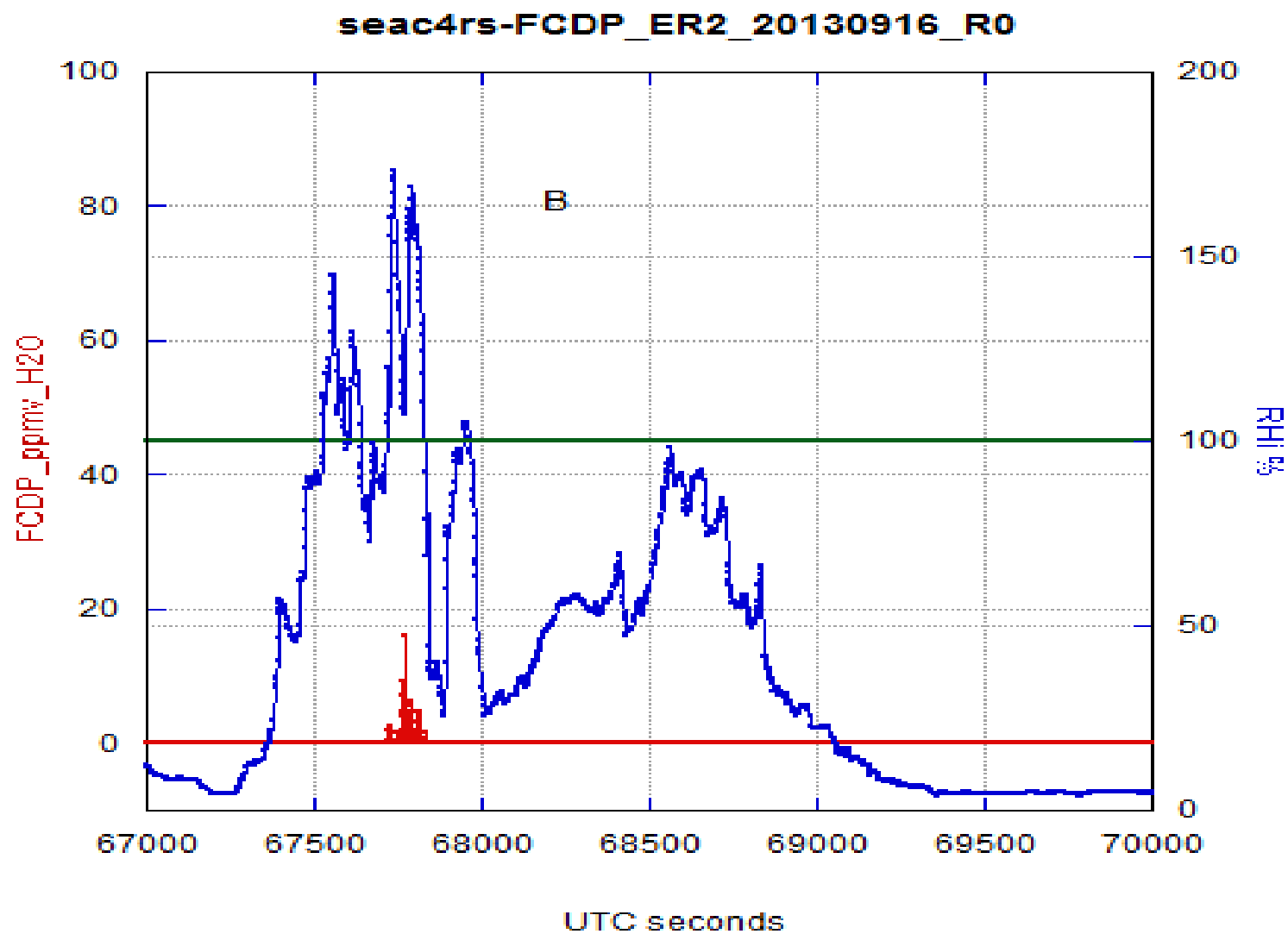
- Jensen et al, PNAS *1217104110*, p2041-2046, January 22, 2013
- Homogeneous freezing responsible for high ice numbers in thin layers
- Heterogeneous freezing responsible for low ice numbers over larger regions, above, below and in the absence of high ice concentration layers



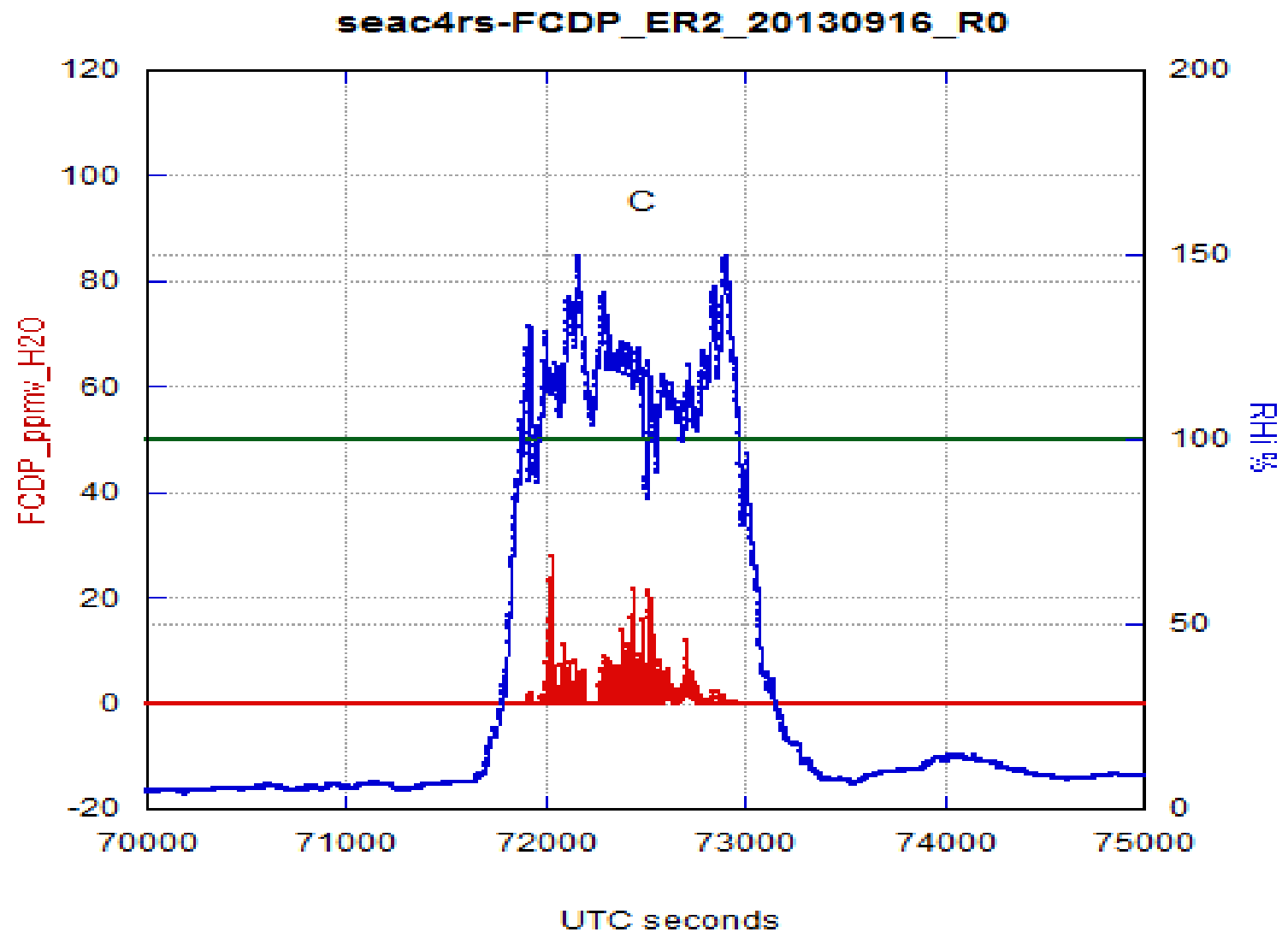
- using FCDP measurements expressed as water
- cirrus observed when  $RH_i > 100\%$
- $RH_i\%$  from Murphy & Koop, 2005



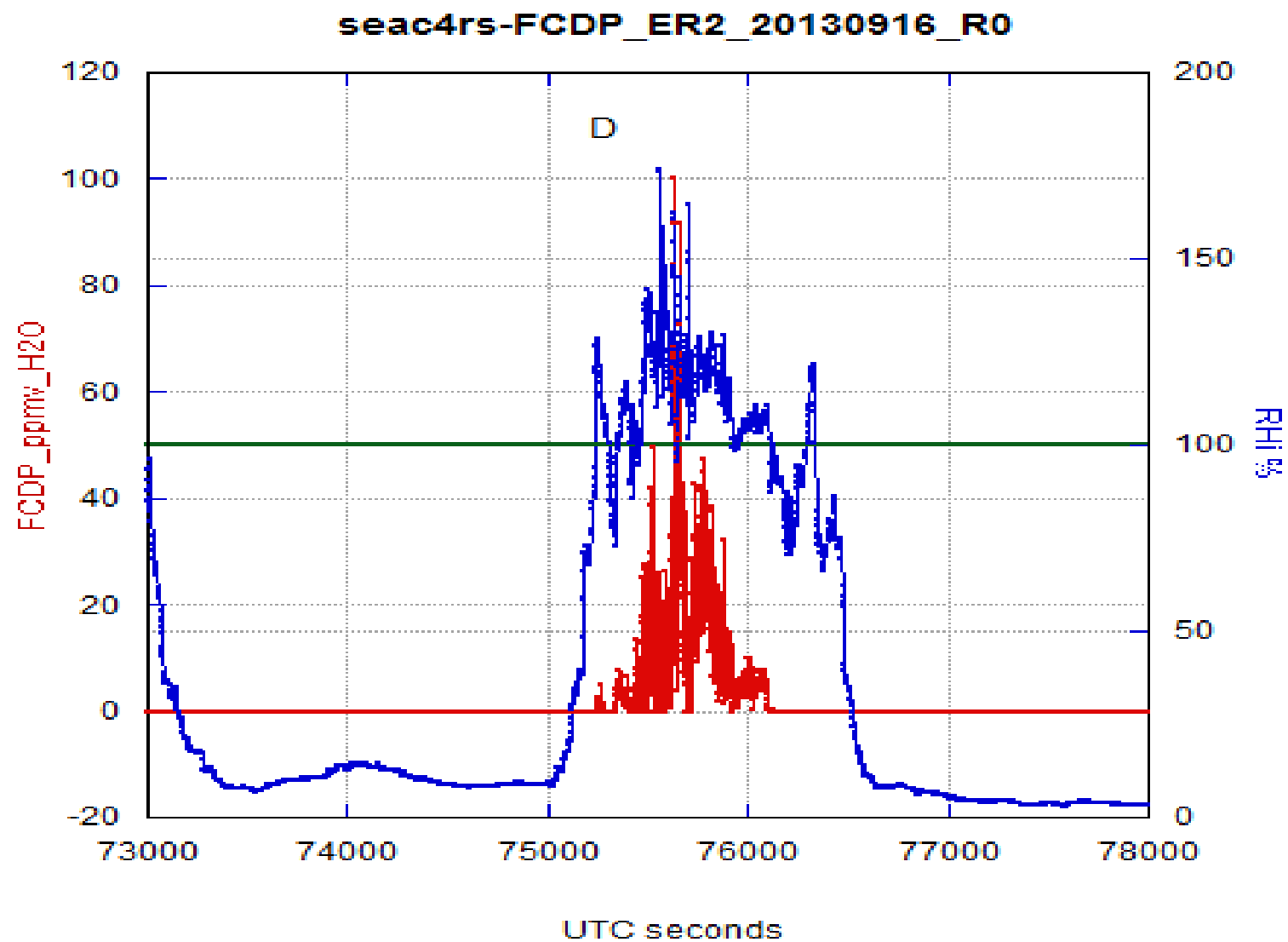
-‘A’ cloud edges well constrained by  $R_{hi} > 100\%$



- 'B' cloud only partially defined by  $R_{hi} > 100\%$  ?

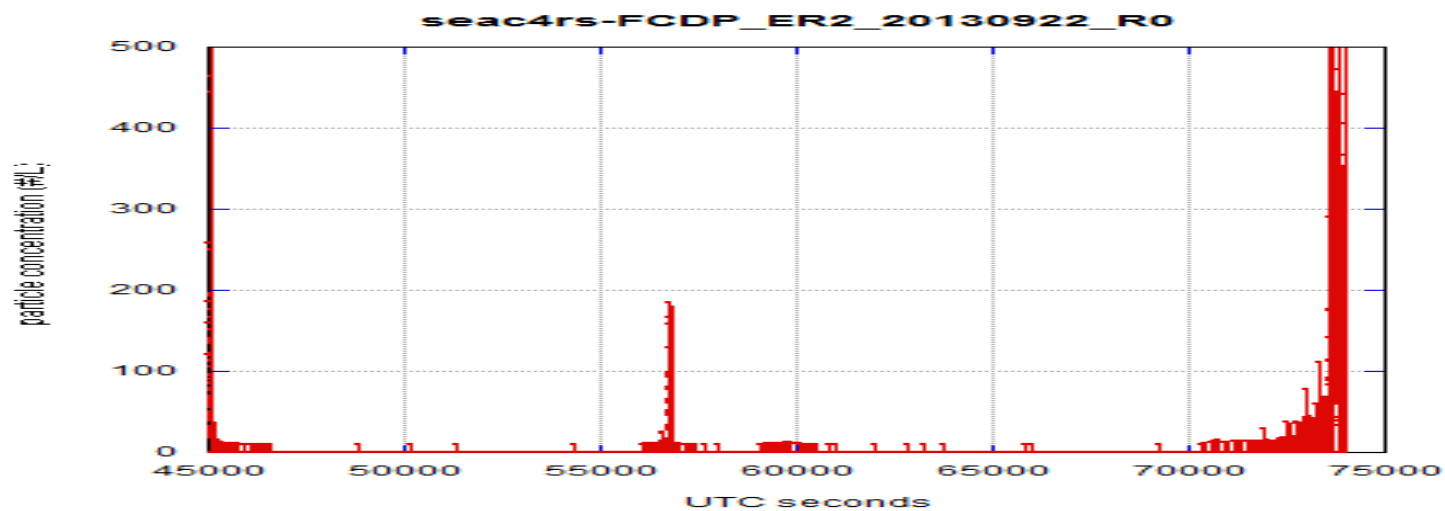
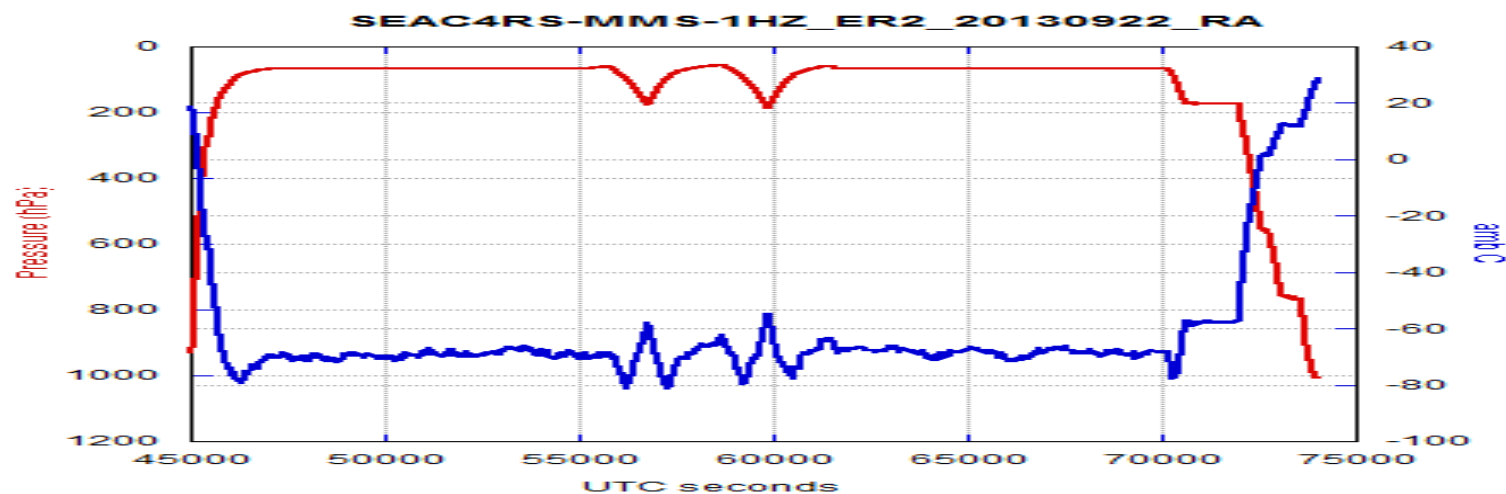


- 'C' cloud pretty well defined by  $\text{Rhi} > 100\%$  ?

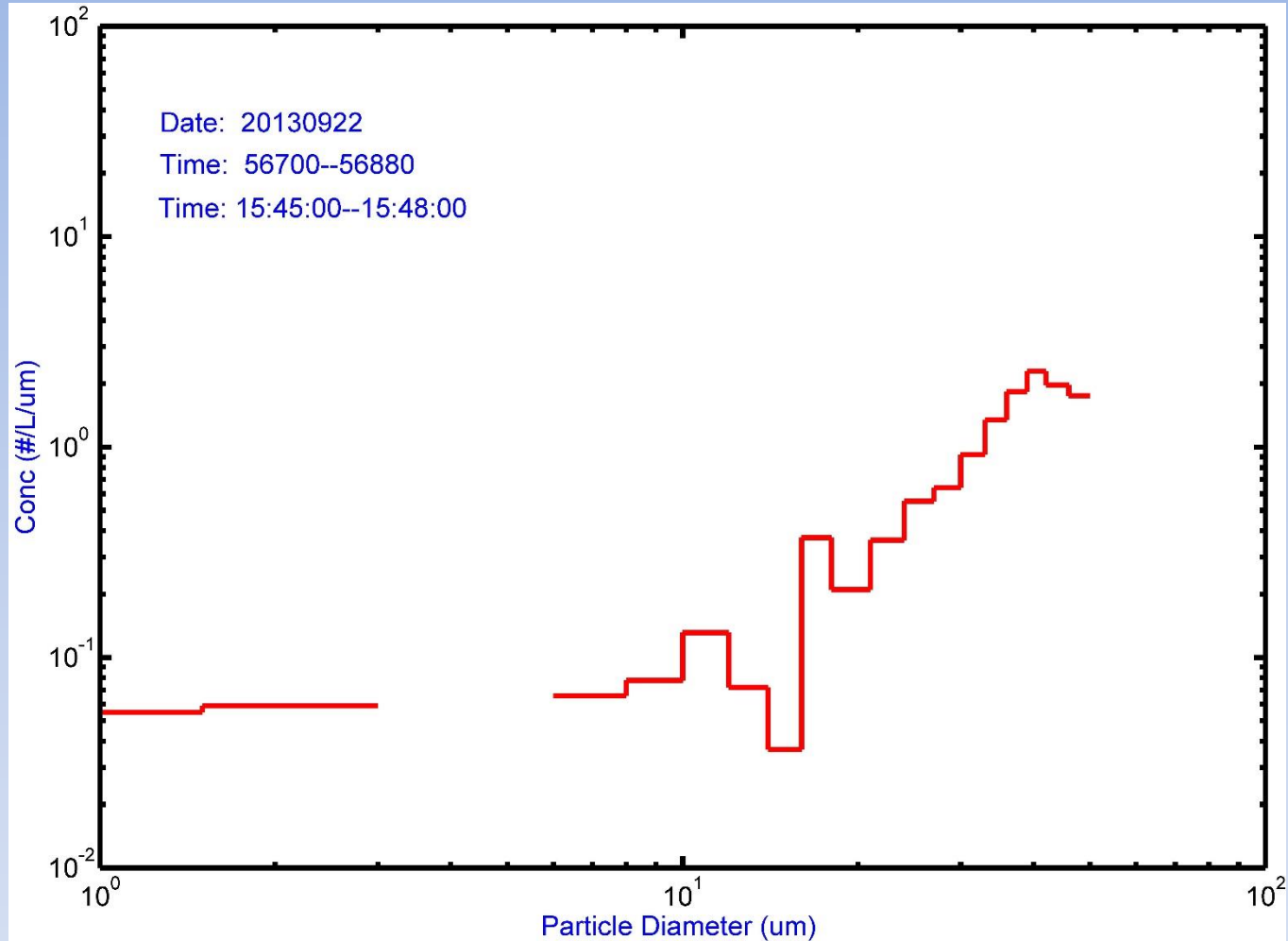


- 'D' cloud pretty well defined by  $R_{hi} > 100\%$

# 20130922 flight SF19

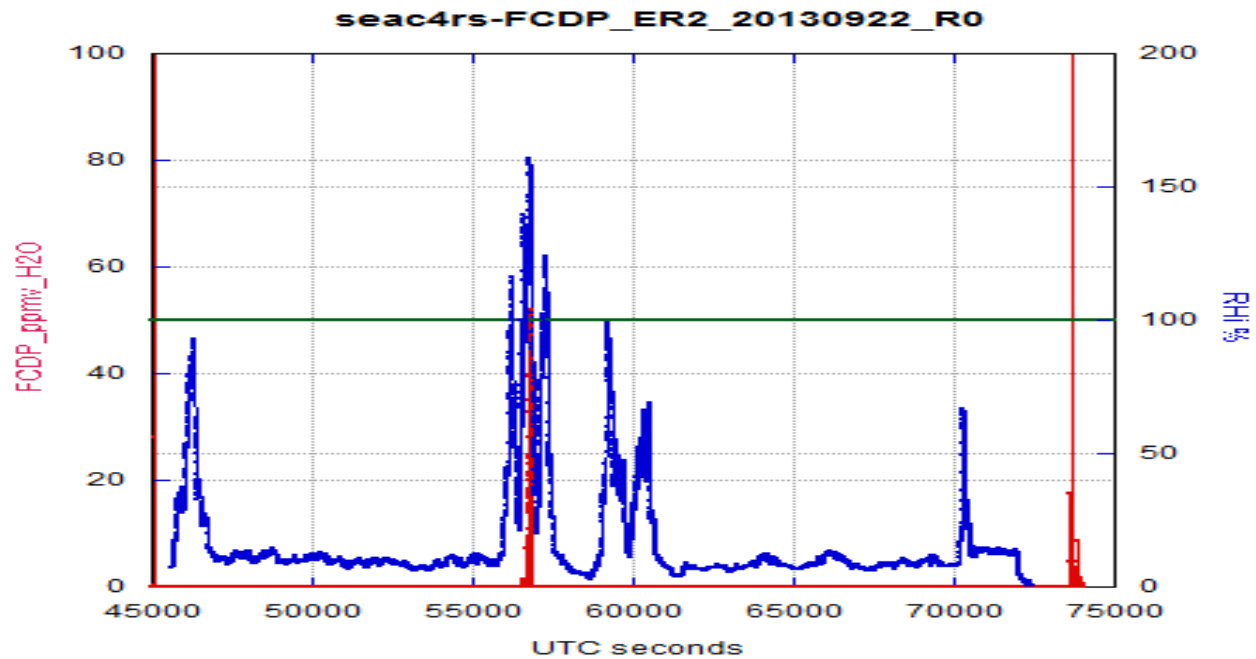


# 20130922 cirrus PSD

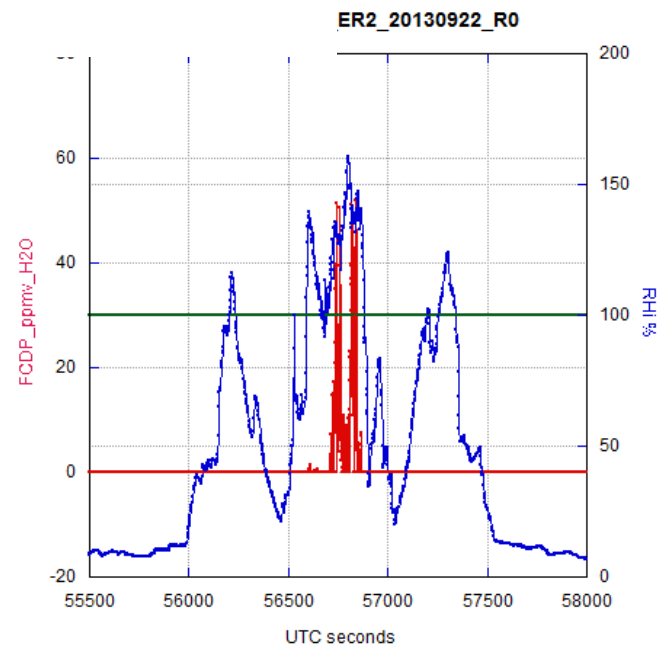


- also particles in 'over' bin
- water mass tied up in larger particles

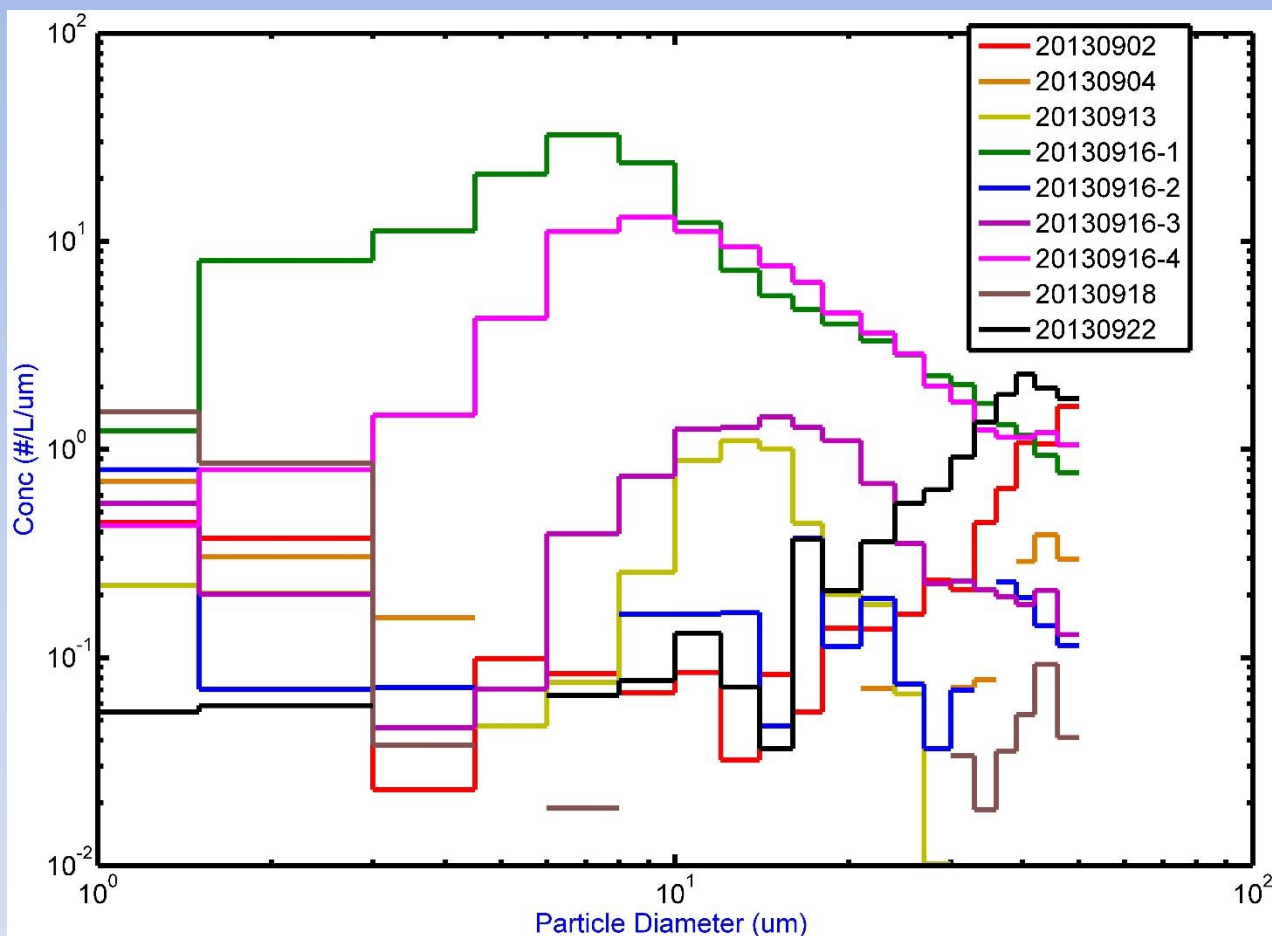




-FCDP measurements expressed as water  
-cirrus observed when RH larger than 120%



# Size distributions from all clouds



-both homogeneous & heterogenous regimes were sampled during SEAC4RS

# SEAC4RS results to date:

- agreement with ATTREX 2011 & 2013 showing 2 categories of cirrus, high & low ice concentrations corresponding to homogeneous and heterogeneous freezing respectively
- 2 cloud intercepts show cirrus concentrations greater than  $1000 \text{ L}^{-1}$  in thin layers, usual size mode is under  $10\mu$  diameter
- all clouds show cirrus concentrations in the  $1\text{-}200 \text{ L}^{-1}$  range over larger extent, usual size mode is over  $10\mu$  diameter

# Acknowledgements:

- SPEC Inc. grant funding from NASA headquarters
- NASA Dryden Aircraft Operations Facility
- ER2 ground and flight crews
- ESPO at NASA Ames Research Center
- and all of the science participants



# SEAC4RS ER-2 Payload

